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PROVISIONAL SPECIFICATION

# Improvements in or relating to the Moulding of Lenses, Prisms and like Optical Elements from Plastics

I, JOHN JOHNSON, a British Subject, of Plasta Works, Bath Road, Slough, Buckinghamshire, do hereby declare the nature of this invention to be as follows:—

This invention consists of improvements in or relating to the moulding of lenses, prisms and like optical elements from plastics and has particular reference to the delicate and refined methods of ensuring correct optical properties in lenses and the like which are composed of clear transparent plastics and are moulded in hot moulds. The plastics referred to include methyl methacrylate polymer and polystyrene and they also include other clear, transparent, thermoplastic substances. Such material will hereinafter be referred to as "plastic".

Patent No. 416,398 describes a method of manufacturing optical lenses which consists in moulding to the required form between dies whose surfaces are highly polished at a temperature so low as not to injure the highly polished surface of the die a transparent material which is sufficiently plastic to be moulded at such a temperature.

Patent specification No. 556,743 describes a method for the production of lenses, prisms and like optical elements from transparent thermoplastic materials such as methyl methacrylate polymer or polystyrene in which a solid workpiece is preformed by cutting, grinding or like mechanical operations to a shape closely approximating to its final shape and the preformed workpiece is heated and then subjected to moulding in accurate dies to ensure that the element has the shape and surfaces of the optical accuracy demanded. That specification also describes apparatus for carrying out the final moulding step.

The present invention is applicable to the moulding of lenses, prisms and like optical elements, the surfaces of which have to be of optical precision, but the invention will be described in relation to the moulding of lenses.

If a preformed blank of plastic is of suitable shape and size in readiness for the final moulding operation, the possibility of errors in moulding may arise from any of the following causes:—(a) The dies (generally of hardened steel) will be of different shape at the temperature at which the plastic solidifies from that which they attain at the temperature at which they were made. (b) The plastic will have a different size and shape at the temperature at which it solidifies from those it attains at the temperature at which it is used. (c) Distortion of the plastic may take place if the solidification of the plastic does not take place uniformly and simultaneously throughout its bulk.

It has been found in practice that any error due to change of shape of the dies can be readily allowed for if steps are taken to ensure that the dies are always heated and cooled in the same manner, preferably from their back surfaces, and also to ensure that during heating and cooling all parts of each back surface are kept at the same temperature.

In the same way the possibility of error under (b) can be readily dealt with if the same technique of heating and cooling is used consistently.

I have found that in certain cases the possibility of error referred to under (c) may have a definite and noticeable effect on the optical properties of the lens especially where one part of the lens is much thicker than another.

It will be appreciated that in the moulding of a flat disc with parallel sides if the die surfaces were isothermal and if the sheet were of uniform thickness, no distortion would occur.

Considering next the moulding of a thick bi-convex lens, during the cooling, the centre portions of the metal dies will reach the solidifying temperature of the plastic before the peripheries of the dies do so (if the back surfaces of the dies are flat and are cooled isothermally) but as the plastic itself is a heat insulator the outer edge or periphery of the lens will solidify earlier than the central portion. Then during the solidification of the central portion (surrounded as it is by

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occur.

Considering the moulding of a thick concave lens, the central portion of the lens will solidify before the periphery and distortion may occur.

Generally speaking steeply curved die surfaces militate against uniform cooling of the softened plastic. Owing to the high coefficient of expansion of the plastic, any errors or variations in the degree of preheating of the preformed plastic blank may tend to exaggerate the difficulties caused by unequal solidification of the thick plastic mass.

According to this invention the making of lenses, prisms and like optical elements from plastics by the general method of preheating the dies and preheating the pre-formed plastic blank and then moulding is characterised by the fact that only the outer layer or skin of the blank is preheated to the softening temperature so that the interior of any thick portion of the plastic blank remains solid during moulding and any movement or flow of plastic during moulding or solidification is confined to the outer layer or skin.

The nature of this invention and of subsidiary features thereof will be appreciated from the following description of specific examples of lens moulding.

A plastic blank is prepared by trepanning from plastic sheet a circular disc 3% less in diameter than the finished lens. The blank is then machined in a lathe with formed cutters so that the radius of each convex surface is 3% shorter than that in the finished lens (and so that the radius of each concave surface is 3% longer than that in the finished lens). The machined surfaces are then smoothed with fine emery paper while the blank is in the lathe. The shaped blank is then buffed to remove tool marks and give a smooth optical finish so that the blank can be easily and visibly cleaned before the moulding operation. The preformed blanks of plastic are carefully cleaned and are stored at a uniform temperature near the temperature at which the finished lenses will be used (for example they may be stored in a thermostat cabinet at 25° C. long enough to ensure that the blanks are uniformly at that temperature).

The blanks are now placed in a thermostatically-controlled electric preheating oven for quite a short period (say 3 minutes). For blanks made of methyl methacrylate polymer a convenient temperature is 250° C. For blanks made from polystyrene a convenient temperature is 200° C. The effect of this short heating at these relatively high temperatures is to soften the outer layer or skin of the blank leaving the internal portion solid.

The dies are heated at the same time to the moulding temperature, say 130° C. for methyl methacrylate polymer and 120° C. for polystyrene. It is convenient to synchronise the heating of the dies with the preheating of the lenses so that the dies are at the correct moulding temperature when the blank is removed from the preheating oven. Each blank is then transferred to the heating dies, the press is closed, the pressure applied to effect the moulding and the cooling is allowed to take place not more rapidly than at the rate of 15° C. per minute. In the operation described regularity and consistency of technique are important: thus the transference of the blanks from the oven to the press must be done as quickly as possible and the actual time taken for the transfer and for the closing of the press should be kept the same for successive operations.

A safe temperature to remove the finished lenses from the press is 50° C. It is found that in the conditions above described the depth of the outer layer of plastic which is heated to a temperature above the softening point is about 1.5 mm. so that independently of the shape of the lens the material which undergoes actual moulding is equivalent to a plane flat sheet 3 mm. thick and any distortion due to the fact that the softened plastic does not solidify simultaneously throughout its bulk is therefore practically eliminated.

Dated this 6th day of September, 1943.
BOULT, WADE & TENNANT,
111 & 112, Hatton Garden,
London, E.C.1,
Chartered Patent Agents.

COMPLETE SPECIFICATION

## Improvements in or relating to the Moulding of Lenses, Prisms and like Optical Elements from Plastics

I, JOHN JOHNSON, a British Subject, of Plasta Works, Bath Road, Slough, Buckinghamshire, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained

in and by the following statement:—

This inventi n consists of improvements in or relating to the moulding of lenses, prisms and like optical elements from plastics and has particular reference to the delicate and refined methods of ensuring correct optical properties in lenses and the like which are composed of clear transparent plastics and are moulded in hot moulds. The plastics referred to include methyl methacrylate polymer and polystyrene and they also include other clear, transparent, thermoplastic substances. Such material will hereinafter be referred to as " plastic ".

Patent No. 416,398 describes a method of manufacturing optical lenses which consists in moulding to the required form, between dies whose surfaces are highly polished, and at a temperature so low as not to injure the highly polished surface of the die, a transparent material which is sufficiently plastic to be moulded at such a temperature.

Patent specification No. 556,743 describes a method for the production of lenses, prisms and like optical elements from transparent thermoplastic materials such as methyl methacrylate polymer or polystyrene in which a solid workpiece is preformed by cutting, grinding or like mechanical operations to a shape closely approximating to its final shape and the preformed workpiece is heated and then subjected to moulding in accurate dies to ensure that the element has the shape and surfaces of the optical accuracy demanded. That specification also describes apparatus for carrying out the final moulding step.

The present invention is applicable to the moulding of lenses, prisms and like optical elements, the surfaces of which have to be of optical precision, but the invention will be described in relation to the moulding of lenses.

If a preformed blank of plastic is of suitable shape and size in readiness for the final moulding operation, the possibility of errors in moulding may arise from any of the following causes:—(a) The dies (generally of hardened steel) will be of different shape at the temperature at which the plastic solidifies from that which they attain at the temperature at which they were made. (b) The plastic will have a different size and shape at the temperature at which it solidifies from those it attains at the temperature at which it is used. (c) Distortion of the plastic may take place if the solidification of the plastic does not take place uniformly and simultaneously throughout its bulk.

It has been found in practice that any error due to change of shape of the dies can be readily allowed f r if steps are taken to ensur that the dies are always heated and cooled in the same manner, preferably from their back surfaces, and also to ensure that during heating and cooling all parts of each back surface are kept at the same temperature.

In the same way the possibility of error under (b) can be readily dealt with if the same technique of heating and cooling is used consistently.

I have found that in certain cases the possibility of error referred to under (c) may have a definite and noticeable effect on the optical properties of the lens especially where one part of the lens is much thicker than another.

It will be appreciated that in the moulding of a flat disc with parallel sides if the die surfaces were isothermal and if the sheet were of uniform thickness, no distortion would occur.

Considering next the moulding of a thick bi-convex lens, during the cooling, the centre portions of the metal dies will reach the solidifving temperature of the plastic before the peripheries of the dies do so (if the back surfaces of the dies are flat and are cooled isothermally) but as the plastic itself is a heat insulator the outer edge or periphery of the lens will solidify earlier than the central portion. Then during the solidification of the central portion (surrounded as it is by the solidified periphery) distortion may occur.

Considering the moulding of a thick concave lens, the central portion of the lens will solidify before the periphery and distortion may occur.

Generally speaking steeply curved die surfaces militate against uniform cooling of the softened plastic. Owing to the high coefficient of expansion of the plastic, any errors or variations in the degree of preheating of the preformed plastic blank may tend to exaggerate the difficulties caused by unequal solidification of the thick plastic mass.

According to this invention the making of lenses, prisms and like optical elements from plastics by the general method of preheating the dies and preheating the pre-formed plastic blank and then moulding is characterised by the fact that only the outer layer or skin of the blank is preheated to the softening temperature so that the interior of any thick portion of the plastic blank remains solid during moulding and any movement or flow of plastic during moulding or solidification is confined to the outer layer or skin.

The nature of this invention and of subsidiary features thereof will be appreciated from the following description of specific examples of lens moulding.

l ns. The blank is then machined in a lathe with formed cutters so that the radius of each convex surface is 3% shorter than that in the finish d lens (and so that the radius of each concave surface is 3% longer than that in the finished lens). The machined surfaces are then smoothed with fine emery paper while the blank is in the lathe. The shaped blank is then buffed to remove tool marks and give a smooth optical finish so that the blank can be easily and visibly cleaned before the moulding operation. The preformed blanks of plastic are carefully cleaned and are stored at a uniform temperature near the temperature at which the finished lenses will be used (for example they may be stored in a thermostat cabinet at 25° C. long enough to ensure that the blanks are uniformly at that temperature).

The blanks are now subjected for quite a short period to externally applied heat, for example, they are placed in a thermostatically-controlled electric preheating oven for quite a short period (say 3 minutes). For blanks made of methyl methacrylate polymer a convenient temperature is 250° C. For blanks made from polystyrene a convenient temperature is 200° C. The effect of this short heating at these relatively high temperatures is to soften the outer layer or skin of the blank leaving the internal portion solid.

The dies are heated at the same time to the moulding temperature, say 130° C. for methyl methacrylate polymer and 120° C. for polystyrene. It is convenient to synchronise the heating of the dies with the preheating of the lenses so that the dies are at the correct moulding temperature when the blank is removed from the preheating oven. Each blank is then transferred to the heated dies, the press is closed, the pressure applied to effect the moulding and the cooling is allowed to take place not more rapidly than at the rate of 15° C. per minute. In the operation described regularity and consistency of technique are important: thus the transference of the blanks from the oven to the press must be done as quickly as possible and the actual time taken for the transfer and for the closing of the press should be kept the same for successive operations.

A safe temperature to remove the finished lenses from the press is 50° C. It is found that in the conditions above described the depth of the outer layer of plastic which is heated to a temperature actual moulding is equivalent to a plane flat sheet 3 mm. thick and any distortion due to the fact that the softened plastic does not solidify simultaneously throughout its bulk is therefore practically eliminated.

In the described example of a method embodying this invention the short application of external heat to the surfaces of the plastic blank was effected in an oven.

In an alternative method the short application of external heat to the surfaces of the plastic blank may be effected through the dies themselves as described in Specification No. 1581/44 (Serial No. 572,748).

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Method of making lenses and like optical elements from plastics by preheating the dies and the preformed plastic blank and then moulding characterised by the fact that only the outer layer or skin of the blank is preheated to the softening temperature so that the interior of any thick portion of the plastic blank remains solid during moulding and any movement or flow of plastic during moulding or solidification is confined to the outer layer or skin.

2. A method of moulding optical lenses from plastics in which a preformed blank of plastic is subjected for quite a short period (say 3 minutes) to externally applied heat to soften only the outer layer or skin of the blank leaving the internal portion solid after which the blank is moulded between optically accurate dies and allowed to solidify by slow cooling of said dies while the die pressure is maintained.

3. A method as claimed in Claim 2 in which the preformed blank is introduced for a short period into an electric preheating oven at a temperature well above the softening temperature (e.g. 250° C. for blanks made of methyl methacrylate polymer or 200° C. for blanks made of polystyrene).

4. A method as claimed in Claim 2 in which the preformed blank is subjected for a short period to externally applied heat by being gently gripped between the dies which are themselves temporarily heated to a temperature well above the softening temperature of the plastic.

5. A method of moulding optical lenses from plastics as claimed in Claim

2 or 3 or 4, in which (a) a plastic blank is prepared by trepanning from plastic sheet a circular disc about 3% less in diameter than the finished lens, (b) the blank is machined and ground in a lathe so that the radius of each convex surface is about 3% shorter than that in the finished lens (and so that the radius of each concave surface is 3% longer than that in the finished lens) and (c) the heating and moulding operations take place.

6. The complete method for the moulding of lenses substantially as described.

Dated this 6th day of September, 1944.

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